Dissodactylus nitidus Smith A E F
Pinnixa transversalis (Milne Edwards & Lucas) A E F
Pinnixa tomentosa Lockington B E F
Pinnixa occidentalis Rathbun B
Pinnixa affinis Rathbun A
Tetrias scabripes Rathbun C

CYMOPOLIIDAE

Cymopolia zonata Rathbun C E F
Cymopolia lucasii (Rathbun) C
Cymopolia fragilis Rathbun A

GRAPSIDAE

Grapsus grapsus (Linnaeus) A E F
Geograpsus lividus (Milne Edwards) A E F
Goniopsis pulchra (Lockington) A E
Pachygrapsus crassipes Randall A B E
Pachygrapsus transversus (Gibbes) A E
Planes minutus (Linnaeus) A B E
Planes marinus Rathbun B
Goetice americanus Rathbun C E F
Tetragrapsus jouyi (Rathbun) C E F
Sesarma (Sesarma) sulcatum Smith A E F
Sesarma (Holometopus) magdalenensis Rathbun C E F
Cyclograpsus escondidensis Rathbun C E
Plagusia depressa tuberculata Lamarck A
Percnon gibbesi (Milne Edwards) A E F

GECARCINIDAE

Cardisoma crassum Smith A;
Ucides occidentalis (Ortmann) A
Gecarcinus planatus Stimpson A E

OCYPODIDAE

Ocypode occidentalis Stimpson A E F
Uca monilifera Rathbun C E
Uca princeps (Smith) A
Uca mordax (Smith) A E F
Uca brevifrons (Stimpson) A
Uca macrodactylus (Milne Edwards & Lucas) A
Uca crenulata (Lockington) B D E
Uca coloradensis (Rathbun) C E
Uca musica Rathbun C E F
Uca latimanus (Rathbun) A E

ZOOLOGY.—*The morphology and development of the preparasitic larvae of* Poteriostomum ratzii.[1] JOHN T. LUCKER, Bureau of Animal Industry. (Communicated by BENJAMIN SCHWARTZ.)

INTRODUCTION

The preparasitic larvae of the numerous species of small strongyles (Strongylidae of genera other than *Strongylus*) parasitic in the large intestine of horses have not been described, except in the case of *Triodontophorus tenuicollis*. The literature relating to this group of nematodes contains a number of publications dealing with the structure and development of their free-living larvae, but the available information is without reference to species, with the one exception noted above. The following is a brief summary of the literature pertaining to the preparasitic development of the small strongyles of horses.

In 1866, Baillet (3) published observations on the preparasitic development of *Sclerostoma tetracanthum* Diesing, 1851. As is well

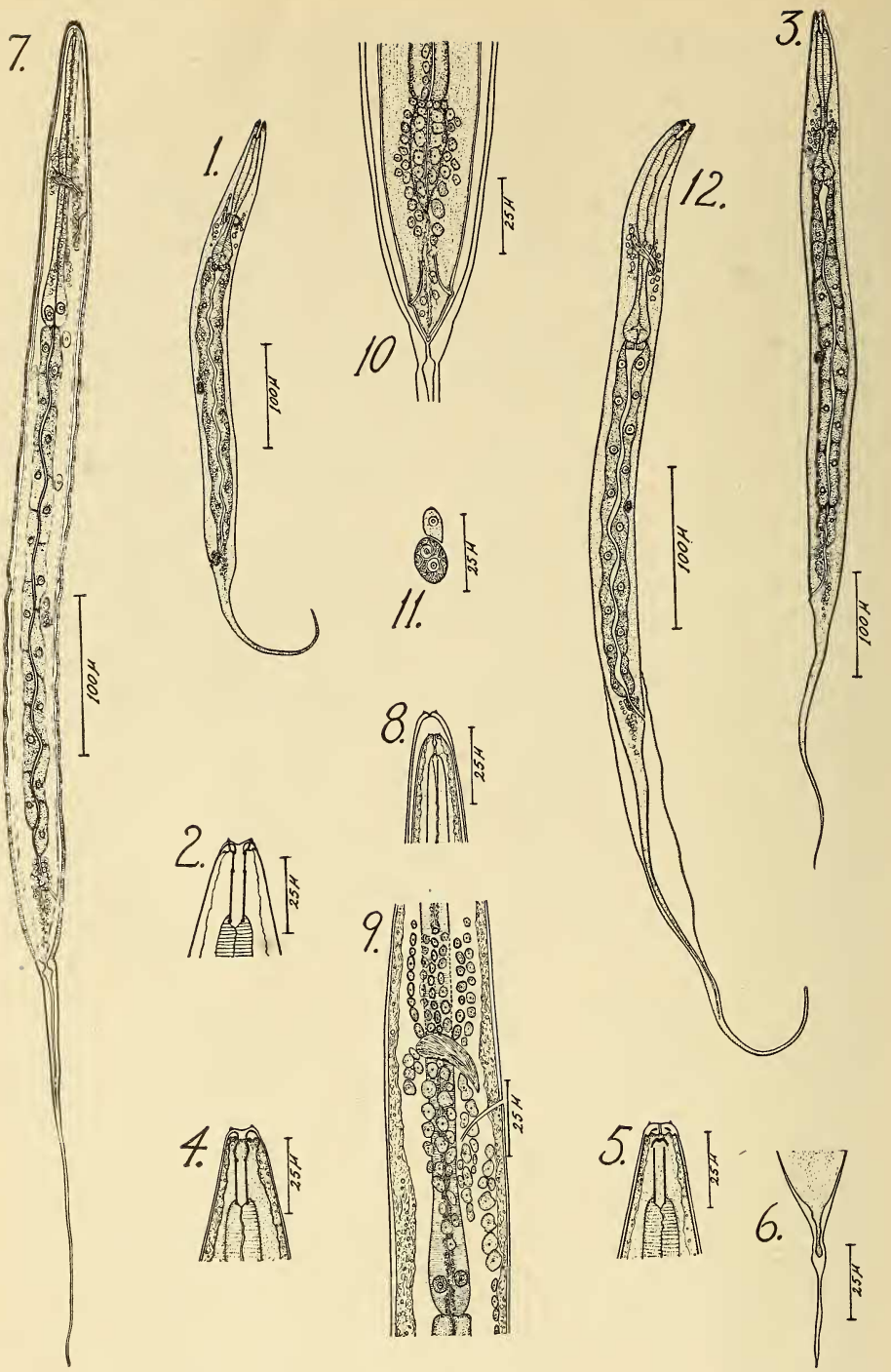
[1] Received March 2, 1934.

known, *S. tetracanthum* (Synonyms: *Strongylus tetracanthus* Mehlis, 1831; *Cyathostomum tetracanthum* Molin, 1861) was shown by Looss (9) in 1901 to be a composite of at least 13 distinct species. Subsequently the species which comprised the *S. tetracanthum* complex have been found to represent several distinct genera. Giles (6), Albrecht (1), Theiler (15), De Blieck (4), De Blieck and Baudet (5) and Poluszynski (11) have reported investigations on the preparasitic development of specifically unidentified cylicostomes. The morphological data in the above papers are incomplete; even Ortlepp's (10) description of the infective larva of *Triodontophorus tenuicollis* is not as detailed as is necessary for the differential diagnosis of the larvae in question. Larval development in the genus *Poteriostomum* apparently has not been previously studied.

The worms from which cultures were made were removed from the colons of two horses at post-mortem examination. Only a few females and one male of the genus *Poteriostomum* were found in the first horse, and three females and one male were recovered from the second horse. The females were washed first in physiological saline solution and subsequently in water. The eggs, removed by dissection of the living worms, were cultured in small glass dishes containing tap water. One culture contained the eggs from two females, and each of 4 cultures contained the eggs taken from a single female. The account of the larval development presented in this paper is based upon data obtained from all 5 cultures. After the eggs had been removed from the female worms each of the latter was fixed separately and cleared later for microscopic examination.

SPECIFIC IDENTITY OF THE ADULT WORMS

All of the female worms, from which eggs were removed for culture, and the two male specimens mentioned above, have been identified by the writer as *Poteriostomum ratzii* Kotlán, 1919, and have been deposited as No. 31026 in the U. S. National Museum Helminthological Collection. In view of the fact that the descriptions and figures relating to this species published by Yorke and Macfie (17), Ihle (7), Theiler (15), Smit (13), Smit and Notosoediro (14) and Wetzel (16) are in disagreement in regard to a number of morphological details, and in no case conform in all respects to the original description given by Kotlán (8), the following brief comments as to certain morphological features of the writer's specimens are in order. There are from 64 to 84 elements in the external leaf crown (Kotlán reported from 60



Figs. 1–12.—*Poteriostomum ratzii.* Preparasitic larval stages.

Fig. 1.—First-stage larva, newly hatched. Fig. 2.—First-stage larva, anterior end. Fig. 3.—Second-stage larva. Fig. 4.—Second-stage larva, anterior end. Fig. 5.—Second-stage larva, anterior end, during late phase of development. Fig. 6.—Late second-stage larva, posterior end. Fig. 7.—Infective (third-stage) larva. Fig. 8.—Third-stage larva, anterior end. External edge of sheath inadvertently omitted. Fig. 9.—Third-stage larva, region of nerve ring. Fig. 10.—Third-stage larva, posterior portion. Fig. 11.—Third-stage larva, genita primordium. Fig. 12.—First-stage larva in first ecdysis.

to 64 elements; Smit noted 44 elements; Wetzel reported from 44 to 46 elements; Ihle counted 98 elements in one specimen). The internal leaf crown contains from 38 to 48 elements (Kotlán reported from 40 to 44 elements; Ihle counted 48 elements in one case; Wetzel reported from 34 to 38 elements; Smit noted 30 elements). The structure of the 4 submedian and 2 lateral papillae corresponds to the descriptions of Ihle and Wetzel and to the figure of Yorke and Macfie. In respect to the shape of the walls of the mouth capsule, the specimens agree closely with the figure of Yorke and Macfie and with the description given by Wetzel. The dorsal ray pattern is similar to that figured by Smit and by Smit and Notosoediro, except that the lateral dorsal rays are even more widely separated from one another than noted by the above mentioned workers.

P. ratzii var. *nanum* of Theiler, which has been redescribed as a sub-species by Popov (12), has been differentiated from *P. ratzii* principally because the postero-lateral rays in the former are without an "accessory" process near their base. A definite small posterior cuticular swelling or process is present on these rays in the males collected by the writer.

DESCRIPTION OF THE EGG, PRE-INFECTIVE AND INFECTIVE LARVAE

Egg

Usually elliptical in shape, but may be slightly narrower at one pole than at the other. Shell thin and transparent. Measurements of a comparatively small number of eggs showed a wide variation in size, namely from 90μ to 125μ in length and from 57μ to 70μ in width. Eggs present in the uterus near the vagina were in the 16- or 32-cell stage. When fully developed the vermiform embryo has the structure of the first-stage larva described below.

First-stage larva

Shape and size.—Fusiform; similar in appearance to rhabditiform larvae of related strongyles, a long filamentous tail comprising about ¼ to ⅓ of the body length (Fig. 1). Newly hatched larvae from 450μ to 470μ long; larvae at time of first molt, 600μ to 620μ long.

Cuticle.—Thin, with very inconspicuous transverse striations.

Alimentary tract.—Mouth opening surrounded by minute papillae, apparently 6 in number. In the rhabditiform buccal cavity, cheilorhabdions and telorhabdions, (Fig. 2) represented by definite refractive cuticular dots; prorhabdions and metarhabdions discernible as short refractive cuticular rods, refractive dots appearing at their junctures. Esophagus rhabditiform; esophageal valve prominent. Esophagus and intestine united by primordium of esophago-intestinal valve; valve consisting of 4 cells and with a short, narrow, straight lumen. Intestinal lumen dilated and sinuous in living

specimens, expanded terminally both anteriorly and posteriorly. In living specimens the intestine dark and granular, consisting apparently of 16 cells. Lumen of rectum narrow, leading to a conspicuous anus. Rectal glands dorsal and subventral to rectum.

Nervous system.—Nerve ring surrounding isthmus of esophagus. Numerous nerve cells situated lateral and ventral to esophagus both anterior and posterior to nerve ring.

Excretory system.—Excretory pore and excretory canal not seen.

Genital primordium.—Primordium minute, oval, transparent, containing 2 germinal cells, situated ventral to and at approximate equator of intestine. In some specimens, genital primordium in close apposition to a smaller, more anterior, oval or spade-shaped cell, presumably the "giant cell" mentioned by Alicata (2) as of significance in sex differentiation in larvae of *Hyostrongylus rubidus.*

The size relationships of 10 first-stage larvae are given below in Table 1.

TABLE 1.—SIZE RELATIONSHIPS OF 10 FIRST-STAGE LARVAE OF POTERIOSTOMUM

ALL MEASUREMENTS IN MICRONS

Specimen number	1	2	3	4	5	6	7	8	9	10
Length	620	554	535	516	474	456	470	583	576	485
Width in region of esophageal bulb	30	32	35	28	26	25	27	29	27	25
Length of buccal capsule	17	15	16	13	13	12	12	14	14	14
Distance from anterior end to nerve ring	102	98	105	90	80	70	70	94	91	82
Length of esophagus	130	129	140	115	122	112	116	121	132	120
Distance from bulb of esophagus to genital primordium	117	141	109	117	102	105	103	127	119	100
Distance from genital primoridum to anus	165	104	120	121	109	118	110	135	122	118
Length of tail	190	174	169	153	130	104	127	186	189	131

Second-stage larva

Shape and size.—Similar in shape to first-stage larva; 600μ to 850μ long, the latter being the approximate maximum length attained during preparasitic stages (Fig. 3). During early phases of this stage, tail increasing considerably in absolute length and, as a rule, in proportionate length also. During transition to strongyliform third stage, tissue of tail loosening from cuticle and contracting to form a short, round-tipped process (Fig. 6).

Cuticle.—Thick and very prominently striated; great thickening occuring in tail region during the later phases of this stage.

Alimentary tract.—In young larvae of this stage, alimentary canal similar to that of first-stage larva. During transition to strongyliform stage the following changes occur: Prorhabdions of buccal capsule at first curving toward each other anteriorly (Fig. 4), later uniting (Fig. 5) to form an inverted V, other portions of the buccal capsule becoming reduced; esophagus lengthening slightly, losing its rhabditiform character and assuming a strongyliform structure; meanwhile esophageal valve disappearing, and primordium of esophago-intestinal valve becoming syncytial; boundaries of intestinal cells becoming more distinct, posterior 2 cells being set off by a constriction as a pre-rectum. Anus appearing somewhat less conspicuous than in first-stage larva.

Nervous system.—Similar to that of the first-stage larva, but nerve cells more prominent.

Excretory system.—Excretory pore and excretory duct clearly visible anterior and ventral to esophageal bulb and just posterior to nerve ring.

Genital primordium.—Similar to that of first-stage larva, but slightly larger and containing a greater number of epithelial cells.

The size relationships of 7 second-stage larvae are shown below in Table 2.

TABLE 2.—Size Relationships of 7 Second-stage Larvae of P. ratzii
All measurements in microns

Specimen number	1	2	3	4	5	6	7
Length	654	830	640	631	790	629	668
Width in region of esophageal bulb	26	37	27	29	35	27	28
Length of buccal cavity	14	19	16	17	19	14	14
Distance from anterior end to nerve ring	101	110	106	93	82	82	90
Distance from anterior end to excretory pore	112	135	117	117	130	93	100
Length of esophagus	138	145	134	139	141	115	135
Distance from bulb of esophagus to genital primoridum	140	165	143	102	159	112	150
Distance from genital primoridum to anus	138	225	136	145	163	148	169
Length of tail	222	279	211	228	310	240	200

Third-stage larva

Shape and size.—Fusiform; tail short, slightly tapering, rather suddenly constricted near its distal end and terminating in a minute, rounded, thumb-like process. Larva from 443μ to 584μ long in 10 specimens. Average width in esophago-intestinal region, about 29μ.

Cuticle.—Thinner than that of second-stage larva and finely striated.

Sheath.—Very thick, with wide, prominent, transverse striae. Two median longitudinal prominences extending along lateral surfaces of sheath; these probably represent lateral alae; sheath conforming closely to shape of larva, but extending posteriorly from 200μ to 255μ beyond posterior tip of larva as a fine tapering cuticular tube or tail; sheath rather sharply constricted just posterior to region normally occupied by larval tail when larva is fully extended. At point of constriction, walls of sheath greatly thickened (Figs. 7, 10) for a short distance, enclosing a very narrow lumen; walls becoming thinner again immediately posteriorly, the narrow lumen mentioned above being very short and followed by a more expanded lumen becoming increasingly narrow as walls converge posteriorly to form tapering distal portion of sheath's tail.

Alimentary tract.—Oral opening surrounded by papillae and followed by a short, narrow, slightly cuticularized tube or canal leading into a minute oval cavity; this cavity communicating with a vestibule by means of a short canal. Vestibule variable in size, but conforming in optical section to the following general plan of structure: Anterior margin of vestibule formed by an inconspicuously cuticularized inverted V, apparently a residue of previous stage prorhabdions; lateral walls cuticular, rather strongly refractive, probably the residuum of metarhabdions of previous stage, converging posteriorly to unite with esophageal lumen; greater part of vestibulum surrounded by esophageal tissue (Fig. 8). Esophagus strongyliform; its lumen highly refractive. Frequently 2 prominent nuclei visible within bulb of esophagus,

presumably being nuclei of esophageal glands. Esophagus leading to a 16-celled intestine; boundaries of intestinal cells definite in young third-stage larvae, but becoming indistinct with exhaustion of reserve food material. Lumen of rectum narrow, leading to an inconspicuous anus.

Nervous system.—Nerve ring slightly posterior to equator of esophagus. In fixed and stained specimens the following details of the nervous system were observed (Fig. 9): 6 narrow chains of nerve cells passing anteriorly from nerve ring about one half distance to cephalic end; nerve fibres not traced from this point anteriorly. A small ganglion posterior and dorsal to nerve ring, laterally a large ganglion passing posteriorly along each side of esophagus and extending nearly to bulb. A ventral ganglion of somewhat smaller size also visible. A chain of nerve cells extending posteriorly from retrovesicular ganglion toward 2 large median ganglia in caudal region. Caudal papillae or phasmids (Fig. 10) about 15μ to 18μ from tip of tail, connecting with tubes or canals passing internally and anteriorly from phasmids. The further course of these canals could not be traced owing to the large number of nerve cells present in this region.

Excretory system.—Excretory pore slightly posterior to nerve ring. Excretory canal or duct passing inward and posteriorly from excretory pore to join a transverse excretory duct. A cross section of lumen of transverse duct visible in optical section of living specimen. Walls of transverse duct contracting and expanding at irregular intervals.

Genital primordium.—Gross appearance similar to that of preceding stages, its position being ventral to the fourth and fifth ventral intestinal cells. The two large germinal cells rather centrally located and surrounded by 11 epithelial cells (Fig. 11). In addition to the "giant cell" near genital primordium, 3 similar cells occuring in body cavity anterior to genital primordium.

The size relationships of 10 third-stage larvae are given below in Table 3.

TABLE 3.—SIZE RELATIONSHIPS OF 10 THIRD-STAGE LARVAE OF P. RATZII
ALL MEASUREMENTS IN MICRONS

Specimen number	1	2	3	4	5	6	7	8	9	10
Length of sheath	737	845	649	706	685	743	712	802	718	762
Distance from posterior end of larva to posterior tip of sheath	211	261	206	253	242	232	205	253	211	220
Length of larva	526	584	443	453	443	511	507	549	507	542
Width of larva in region of esophageal bulb	26	31	20	28	29		24	30		26
Width of sheath in region of esophageal bulb	34	35	25	34	35		30	34		34
Distance from anterior end to nerve ring	94		77	91	90	99	96	98	96	108
Distance from anterior end to excretory pore	115		96	110	110	118	115	115	121	120
Length of esophagus	183	180	162	148	158	180	174	173	180	179
Distance from bulb of esophagus to genital primordium	141	183	124	142	112	146	120	134	149	172
Distance from genital primordium to anus	166	179	117	130	142	151	180	205	146	149
Length of tail	36	40	32	30	34	34	34	38	31	42

DEVELOPMENT OF PREPARASITIC LARVAL STAGES

In water cultures at room temperatures (20° to 26° C.), most eggs contained a vermiform embryo 24 hours after the cultures were pre-

pared. Some eggs hatched within 22 hours and nearly all of the eggs hatched within 40 hours. When the first-stage larvae issued from the eggs, a small amount of helminthologically sterile fecal extract was added to the culture medium. In one culture, after 67 hours of incubation, larvae were observed in the act of casting off the first cuticle (Fig. 12). While the first molt was not actually observed, in two other cases a large number of discarded sheaths were found in the culture dishes examined 72 hours after the cultures were started. In these two cultures all larvae were still in the first stage after 48 hours. Third-stage larvae were found in some cases as early as 115 hours after the cultures were prepared. The thick cuticle of the second-stage larva was not cast off, but was retained by the third-stage larva as a sheath.

SUMMARY

The first-stage larva of *P. ratzii* hatches from the egg in from 22 to 40 hours when kept in water cultures at room temperature (20° to 26° C.); the larva is rhabditiform, varies in length from 450μ to 620μ, and is provided with a long filamentous tail.

The first molt was observed after about 67 hours in a water culture to which helminthologically sterile fecal extract had been added shortly after the first-stage larvae issued from the eggs.

The early second-stage larva is similar to larvae of the preceding stage except that its cuticle is thick and prominently striated. Shortly after the first molt, the excretory pore and excretory canal become clearly visible. Second-stage larvae are from 600μ to 850μ long.

As development proceeds, the second-stage larva becomes further differentiated morphologically. Following the formation of a new cuticle and the attainment of the strongyliform structure, the old cuticle loosens from the body and the larva enters the ensheathed third stage. The second cuticle is not cast off.

The third-stage strongyliform larva has a short tail and is from 443μ to 585μ long. The sheath in which the larva is enclosed is from 650μ to 850μ long, and is characterized by great thickening of its walls in the region immediately posterior to that occupied by the tail of the fully extended larva. A minimum of 115 hours was required for the development from the uterine egg to the infective larva.

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ORNITHOLOGY.—*The hawks of the genus* Chondrohierax.[1] HERBERT FRIEDMANN, U. S. National Museum.

The hook-billed kites of the genus *Chondrohierax* have always been a source of much confusion to taxonomists because of their unusual range of variation in color and size and because of their scarcity in collections. Recently while working over these birds, I

[1] Published by permission of the Secretary of the Smithsonian Institution. Received March 21, 1934.